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BIOLOGY OF THE FRESHWATER DRUM IN WESTERN LAKE ERIE

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ABSTRACT

Information on the biology of the freshwater drum or sheepshead (*Aplodinotus grunniens*) was collected in Lake Erie during a fishery and limnological study made by the Bureau of Commerical Fisheries in 1957 and 1958. Growth of the sheepshead in 1958 was slower than in 1927, and slower than the growth in most other waters. Males and females grew at the same rate through the 4th year of life, but thereafter the females grew faster. Males required more than 13 years and females 11 years to reach 17 inches. A weight of 2 pounds was attained in the 12th year of life by males and in the 10th year by females. Annulus formation extended from mid-June to early August for age-groups I–IV (2nd through 5th year of life). Younger fish started growth earlier in the season than the older fish, and the larger, faster growing members of an age group began growth earlier than the smaller fish.

The growing season in 1958 ended in early October. Bottom-water temperatures were about 65°F when growth started (mid-June) and 58°F when growth ended. Growth was most rapid in August when temperatures were highest for the year (72°F). Growth of young of the year, but not that of older fish, was positively correlated with temperature during the 1951–57 growing seasons. The sex ratio of the 1958 samples shifted with age; age-groups I–IV contained 54% males, but older age groups had 75% males. Males matured between 7.0 and 15.9 inches (age-groups II–V) and females between 9.0 and 13.4 inches (age-groups III–VII). Spawning in 1958 reached a peak in early July, but extended from mid-June to early August.

INTRODUCTION

Growing concern over major changes in the commercial fishery in Lake Erie prompted the Bureau of Commercial Fisheries to undertake a fishery and limnological survey in 1957–58 with the research vessel *Cisco* to study the distribution, abundance, and biology of the fishes and to measure environmental conditions. The present paper, based on the data gathered during this survey, deals with the biology of one of the most important species in western Lake Erie, the freshwater drum, or sheepshead (*Aplodinotus grunniens*).

Although not highly regarded as a food or sport fish, the freshwater drum has become increasingly important in Lake Erie as stocks of more desirable species have declined or disappeared, and because of the increased demand for drum for animal food. The drum also may occupy a prominent position in the ecology of Lake Erie, because it is one of the most abundant species in the western basin of the lake and competes strongly with other major species. Drum made up 21% by weight of the total catches in bottom trawls by the *Cisco* in western Lake Erie in 1958 and were second only to yellow perch (*Perca flavescens*), which made up 55%. Carp (*Cyprinus carpio*), American smelt (*Osmerus mordax*), and emerald shiners (*Notropis atherinoides*) each made up about 5% of the catch,

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and 30 other species, including many important sport and commercial species, contributed less than 2% each to the total. A study of the food habits of 10 important fishes from western Lake Erie, collected during the 1957–58 survey, demonstrated that smaller drum feed heavily on most of the invertebrate organisms that other forage, sport, and commercial fish depend upon, and that larger drum, like the majority of other species, feed to a considerable extent on small fish (Price, 1963). Drum, however, are eaten infrequently by other fishes. Consequently, the large population in western and west-central Lake Erie represents an important reservoir of competitive and predatory liability that is not subject to control through predation by other fish.

MATERIALS AND METHODS

Materials for this study were collected during 10 cruises of the research vessel *Cisco* in Lake Erie in 1958. Eleven stations in various ecological areas of western and west-central Lake Erie were visited during each cruise (fig. 1). Drum were collected with bottom trawls, patterned after conventional 2-seam North Atlantic

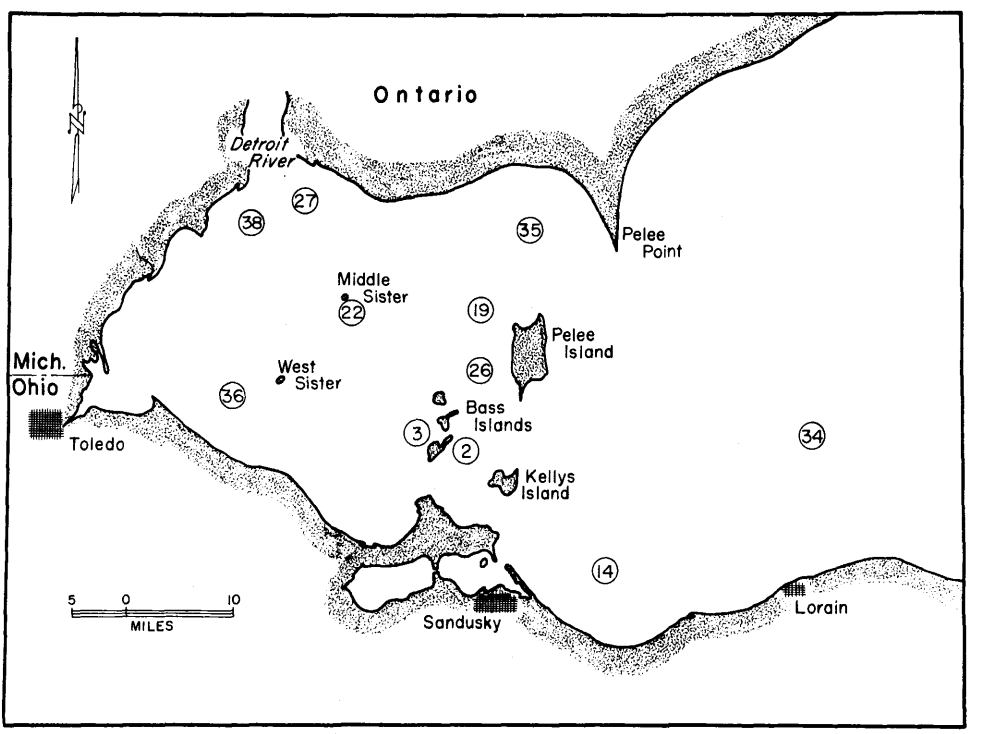

FIGURE 1. Western and west central Lake Erie showing stations of R/V *Cisco* at which data for this study were obtained.

semiballoon trawls. Head and foot ropes were 39 and 51 feet long, respectively; meshes were 3½ inches (extended measure) in the wings and 2½ inches in the body. The cod end was ½-inch mesh and 8 feet long. Trawls were dragged along the bottom parallel to the contours in what were generally 10-minute tows. A temperature profile from the surface to the bottom was obtained with a bathythermograph each time a station was visited.

Representative samples of young-of-the-year drum were measured and preserved for later verification of age. Scale samples for the determination of age

and the back calculation of growth were taken randomly from the catches of older fish. Scales were taken midway between the lateral line and the midpoint of the spiny dorsal fin, and were placed in an envelope on which were recorded the length, weight, sex, condition of gonads, date, and location. Total length was recorded to the nearest 0.1 inch, and weight in pounds and ounces for fish heavier than 1 pound and in ounces and tenths of ounces for smaller fish. Sex and state of maturity were judged by gross examination, and classified by the criteria of Daiber (1953). Impressions of scales were made in cellulose acetate (Smith, 1954) and were examined at a magnification of 42x with a microprojector (Moffett, 1952). Scale measurements for the calculation of growth were made along the anterior radius of the anterior-posterior axis of the scale.

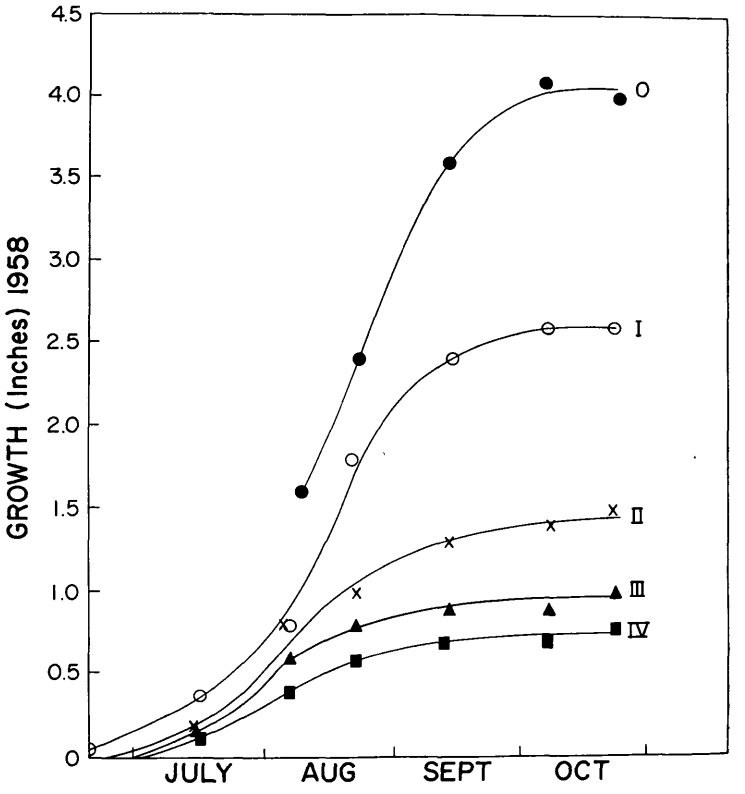

FIGURE 2. Growth in length (inches) of freshwater drum of age-groups 0–IV in 1958. Roman numerals identify the curve of each age group; curves were drawn by inspection.

Ages were recorded as the number of annuli on the scale. Fish with no annulus made up age-group O; those with one annulus, age-group I; those with two annuli, age-group II; . . . . Fish were considered to pass into the next higher age group on January 1 (Hile, 1948).

Of the 1,684 drum in age-group I and older from which scales were examined, 1,505 were assigned ages. A group of 171 drum captured during cruise 7 at stations 2, 3, 14, and 35 was not used because of difficulty in determining if these fish had grown during the calendar year of collection. Eight fish captured at various other times also had scales that were "unreadable." All analyses for fish in age-groups I and older were based on data from the 1,505 fish for which ages

were determined (table 1). Of these, 600 were males, 492 were females, and 413 were immature fish for which sex could not be determined in the field. Growth analyses for 1,562 O-group fish were based on length at time of capture (table 2).

LENGTH AND AGE COMPOSITION

The length distributions of male and female drum in various collections were closely similar (table 3). The average lengths, for all cruises combined, were 11.3 inches for males, 11.2 inches for females, and 6.8 inches for the young unsexed fish.

The average length of drum changed little throughout the period of collection,

TABLE 1

Number of drum in age-groups I and older captured in 1958 from which scales were taken for age and growth analysis

Cruise number	Cruise dates	Station number									Total
		2	3	14	22	27	34	35	36	38	
2	April 13–28	—	—	—	9	—	—	—	—	—	9
3	May 6–19	1	24	—	—	—	14	—	—	—	39
4	May 27–June 8	4	13	5	9	—	—	16	3	—	50
5	June 17–30	48	81	55	48	8	2	39	57	1	339
6	July 9–21	22	28	9	50	—	—	54	37	32	232
7	July 29–Aug. 11	—	—	—	50	—	—	—	17	—	67
8	August 19–30	49	—	20	50	—	—	22	50	—	191
9	Sept. 9–22	50	—	50	17	—	56	55	43	—	271
10	Sept. 30–Oct. 13	51	—	50	—	—	—	45	1	—	147
11	Oct. 21–31	50	—	—	38	—	50	22	—	—	160
Total		275	146	189	271	8	122	253	208	33	1,505

TABLE 2

*Number of age-group 0 drum measured for growth analysis**

Cruise number	Station number										Total
	2	3	14	19	22	26	34	35	36	38	
7	—	—	—	—	—	49	—	—	—	—	49
8	9	—	—	53	56	61	—	—	127	—	306
9	47	44	63	49	58	46	—	57	41	—	405
10	88	52	126	—	4	—	7	42	58	2	379
11	71	68	26	59	26	23	34	62	54	—	423
Total	215	164	215	161	144	179	41	161	280	2	1,562

*Cruise dates are given in table 1. No age-group 0 fish were captured before cruise 7.

except for the unsexed fish, which increased irregularly from 5.3 inches in the spring (cruises 2–4) to 8.1 inches in the late fall (table 3). Differences in the lengths of males or females during the period of collection were small and showed no seasonal trend. The mean length varied among cruises from 10.6 inches to 12.2 inches for males, and from 10.8 inches to 12.1 inches for females. With the exception of the females of cruises 2–4, the range of the modes was narrow (10.5–10.9 inches to 11.5–11.9 inches) and was identical for the sexes. Length differences between males and females during the same cruise were smaller than the seasonal variation for either sex. The greatest difference in average length between the

TABLE 3

*Length distribution of Lake Erie drum**

Length interval (inches)	Cruise																								Total		
	2–4†			5			6			7			8			9			10			11					
	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U
3.0– 3.4	—	—	4	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
3.5– 3.9	—	—	2	—	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10
4.0– 4.4	—	—	8	—	—	25	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	36
4.5– 4.9	—	—	3	—	—	19	—	—	3	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	27
5.0– 5.4	—	—	2	—	—	9	—	—	5	—	—	4	—	—	2	—	—	1	—	—	—	—	—	—	—	—	23
5.5– 5.9	—	—	4	—	1	5	—	—	1	—	—	3	—	—	5	—	—	3	—	—	—	—	—	—	—	1	21
6.0– 6.4	—	—	—	—	—	11	—	—	1	—	—	2	—	—	9	—	—	7	—	—	—	—	—	1	—	—	31
6.5– 6.9	—	—	3	—	1	15	—	—	1	—	—	1	—	—	3	—	—	10	—	1	5	—	—	4	—	2	42
7.0– 7.4	1	1	2	1	5	18	—	—	9	—	—	1	—	—	3	2	1	12	1	—	13	1	—	4	6	7	62
7.5– 7.9	1	2	3	4	5	20	1	2	8	1	4	1	—	3	5	10	5	12	2	1	6	2	2	7	21	24	62
8.0– 8.4	1	—	—	8	2	5	4	2	5	—	1	—	—	3	10	5	1	11	7	1	8	3	6	2	28	16	41
8.5– 8.9	—	—	—	5	6	5	2	4	2	1	1	—	4	5	10	6	8	3	3	4	2	2	3	—	23	31	22
9.0– 9.4	3	2	—	5	4	—	6	3	2	—	—	—	3	3	4	10	7	3	6	3	1	7	1	2	40	23	12
9.5– 9.9	5	1	—	10	5	—	9	5	3	4	2	—	8	3	2	5	3	1	4	3	2	6	4	3	51	26	11
10.0–10.4	5	—	1	11	8	—	11	8	1	2	1	—	3	6	1	13	5	—	1	3	1	5	3	2	51	34	6
10.5–10.9	5	4	—	12	13	—	15	12	—	5	7	—	7	4	—	18	7	—	8	5	—	6	7	1	76	59	1
11.0–11.4	6	1	—	13	15	—	15	15	—	2	4	—	7	12	—	15	8	—	5	5	—	2	5	—	65	65	—
11.5–11.9	5	1	—	8	8	—	11	13	—	—	2	—	10	10	—	10	10	—	6	2	—	11	4	—	61	50	—
12.0–12.4	1	2	—	6	4	—	5	3	—	3	1	—	7	4	—	8	8	—	3	—	—	7	4	—	40	26	—
12.5–12.9	—	—	—	3	6	—	8	8	—	3	—	—	3	4	—	3	6	—	3	1	—	6	6	—	29	31	—
13.0–13.4	1	5	—	4	5	—	3	3	1	2	1	—	4	3	—	2	5	—	4	1	—	5	2	—	25	25	1
13.5–13.9	1	2	—	2	4	—	2	3	—	1	1	—	5	3	—	5	4	—	4	1	—	2	2	—	22	20	—
14.0–14.4	—	2	—	1	1	—	2	2	—	—	1	—	1	1	—	3	1	—	1	3	—	2	2	—	10	13	—
14.5–14.9	1	2	—	1	2	—	1	—	—	—	—	—	1	1	—	2	—	—	2	3	—	1	3	—	9	11	—
15.0–15.4	—	—	—	—	4	—	3	2	—	—	1	—	1	—	—	2	—	—	1	—	—	2	—	—	9	7	—
15.5–15.9	—	—	—	1	1	—	1	1	—	—	—	—	—	1	—	4	—	—	1	1	—	—	1	—	7	5	—
16.0–16.4	—	1	—	—	2	—	—	—	—	1	1	—	1	1	—	1	—	—	—	—	—	—	—	—	3	5	—
16.5–16.9	2	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	—	1	—	—	5	—	—
17.0–17.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	2	1	—	5	1	—
17.5–17.9	—	1	—	—	—	—	—	—	—	1	—	—	—	1	—	—	1	—	1	1	—	1	—	—	3	4	—
18.0–18.4	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	—	—	2	1	—	3	2	—
18.5–18.9	1	—	—	—	—	—	1	1	—	—	—	—	—	—	—	1	—	—	1	1	—	1	—	—	5	2	—
19.0–19.4	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—	—	—	1	1	—
19.5–19.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—
20.0–20.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	—
22.0–22.4	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Total	39	27	32	95	103	141	100	87	45	26	28	14	67	70	54	127	80	63	69	40	38	77	57	26	600	492	413
Average length	11.1	12.1	5.3	10.6	11.1	6.0	11.2	11.3	7.3	11.6	10.9	5.8	11.6	11.4	7.6	11.0	10.8	7.4	12.2	11.4	8.0	12.0	11.4	8.1	11.3	11.2	6.8

*M=Male, F=Female, U=Undetermined sex; cruise dates are given in table 1. †Data from cruises 2, 3, and 4 were combined because few fish were taken.

TABLE 4

*Age composition of Lake Erie drum**

Age group	Cruise																								Total		
	2–4†			5			6			7			8			9			10			11					
	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U	M	F	U
I	—	—	23	—	1	75	—	—	14	—	—	12	—	3	22	13	5	44	6	2	30	5	5	16	24	16	236
II	3	3	8	15	16	64	4	7	25	1	6	2	8	13	28	25	21	17	14	11	7	13	14	8	83	91	159
III	12	4	1	25	18	2	21	14	5	8	5	—	17	16	4	28	19	2	15	11	1	17	7	1	143	94	16
IV	17	7	—	38	41	—	46	47	1	9	12	—	23	25	—	34	29	—	15	5	—	20	21	1	202	187	2
V	2	1	—	5	8	—	14	8	—	5	1	—	3	5	—	7	3	—	3	5	—	6	1	—	45	32	—
VI	1	11	—	10	15	—	9	9	—	1	3	—	10	4	—	9	2	—	6	3	—	6	8	—	52	55	—
VII	1	1	—	1	1	—	2	1	—	1	—	—	1	—	—	4	—	—	1	1	—	3	1	—	14	5	—
VIII	—	—	—	1	—	—	3	—	—	—	—	—	1	2	—	2	—	—	2	—	—	—	—	—	9	2	—
IX	1	—	—	—	2	—	—	—	—	—	1	—	2	—	—	3	—	—	1	2	—	1	—	—	8	5	—
X	1	—	—	—	—	—	—	—	—	1	—	—	—	1	—	—	1	—	3	—	—	2	—	—	7	2	—
XI	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	3	—	—
XII	—	—	—	—	1	—	1	—	—	—	—	—	—	1	—	1	—	—	1	—	—	2	—	—	5	2	—
XIII	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	1	—	—	2	—	—	—	—	—	5	—	—
XIV	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Total	39	27	32	95	103	141	100	87	45	26	28	14	67	70	54	127	80	63	69	40	38	77	57	26	600	492	413
Average age	4.2	4.6	1.3	3.7	4.1	1.5	4.3	4.1	1.8	4.2	3.8	1.1	4.4	3.8	1.7	3.7	3.2	1.3	4.2	3.6	1.2	4.2	3.5	1.5	4.1	3.8	1.5

*M=Male, F=Female, U=Undetermined sex; cruise dates are given in table 1. †Data from cruises 2, 3, and 4 were combined because few fish were taken.

sexes (1.0 inch) occurred in cruises 2–4 and the largest difference in modal length (also 1.0 inch), excluding the females of cruises 2–4, was in cruises 9 and 11.

The age distributions of male and female drum differed significantly. The average age was 4.1 years for all males and 3.8 years for the females, but age-group IV was the modal age for both sexes (table 4). The oldest males were age XIII, and the oldest female was in age-group XIV. The immature fish of undetermined sex were mostly in age-groups I and II, but a few were in age-groups III and IV. The equal division of males and females in age-groups I and II (107 of each sex) suggested that identification of sex in small fish was not easier for one sex than for the other. Thus the difference in mean age of males and females probably was real.

No well-defined seasonal trend in age composition was apparent (table 4), but the mean and modal ages fluctuated among collections. The average age of unsexed fish varied between 1.1 and 1.8 years, and the modal age between age-groups I and II. Age-group IV was dominant for both sexes in all except

TABLE 5

*Relation between total length of fish and magnified scale radius of Lake Erie drum**

Number of fish	Average length of fish	Average scale radius
4	3.2	2.4
5	3.7	3.1
17	4.2	4.0
11	4.7	4.7
11	5.2	5.1
11	5.7	5.9
7	6.3	6.8
17	6.7	7.1
26	7.2	8.2
43	7.7	8.7
27	8.2	9.8
28	8.7	10.4
29	9.2	10.8
29	9.7	12.1
37	10.2	12.4
48	10.7	13.0
47	11.2	13.9
44	11.7	14.9
25	12.1	15.5
19	12.7	16.3
23	13.2	16.8
13	13.6	18.2
12	14.2	18.8
8	14.6	19.9
6	15.2	19.9
5	15.7	21.5
4	16.2	21.3
3	16.6	21.4
3	17.2	24.3
2	17.8	26.0
2	18.4	25.6
2	18.6	24.1
2	19.2	25.6

*Scale radii in millimeters ×42; lengths are true means for 0.5-inch intervals.

cruise 10, when males were most abundant in age-groups III and IV and females in age-groups II and III. The mean age fluctuated, however, ranging from 4.4 years (cruise 8) to 3.7 years (cruises 5 and 9) for males and from 4.6 years (cruises 2–4) to 3.2 years (cruise 9) for females. The seasonal fluctuations in average age of males followed closely those of the females.

BODY-SCALE RELATION

The body-scale relation was determined from scales of 570 drum selected randomly for representation over a wide range of length (table 5). Average anterior scale radii were measured for two or three (average of 2.8) scales from each fish. A plot of average lengths and radii for fish by 0.5-inch-length intervals indicated a linear relationship. The equation of the line fitted by least squares was: $L=1.776+0.664\ S$, where $L=$the total length of fish (inches), and $S=$the anterior scale radius (mm x 42). A value of 1.8 was used as the intercept in calculations of length. This intercept was closely similar to that of 1.9 determined by Larmoyeux (1951) for drum of western Lake Erie.

Disagreements between the grouped data and the graph of the equation were small and did not exceed 0.2 inch for fish 3.2–12.7 inches long, or 0.3 inch for fish as large as 16.2 inches. At greater lengths, disagreements were larger (maximum of 1.2 inches), but the data were randomly distributed about the regression line.

TABLE 6

*Percentage of drum of age-groups I–IV with new scale growth on different dates**

Date of capture	Age group			
	I	II	III	IV
June 19–24	22.4 (76)	1.1 (95)	0.0 (45)	0.0 (79)
July 13–20	92.9 (14)	88.9 (36)	75.0 (40)	58.5 (94)
August 4–8	100.0 (12)	100.0 (9)	100.0 (12)	90.5 (21)

*Number of fish in parentheses.

ANNULUS FORMATION AND SEASONAL GROWTH

New growth for 1958 first appeared on scales of drum captured during June 19–24; by August 4–8, new growth was present on the scales of nearly all fish of age-groups I–IV, the only age groups for which sufficient specimens were available for detailed analysis of annulus formation (table 6). Water temperatures at the bottom in western Lake Erie in 1958 rose to 65°F near the onset of growth (June 19–24) and ranged from 72° to 75°F by August 1–10, when nearly all fish had formed annuli. Butler and Smith (1950) stated that annulus formation on the scales of drum in the upper Mississippi River navigation pools began in early or mid-May and extended to mid-July, but gave no data on water temperature.

Younger drum started growth earlier than older fish (table 6), a characteristic common among many species (Bailey, 1964; Hile, 1941; McFadden, 1959; Smith, 1956; Warner and Fenderson, 1963). New growth was present on the scales of 22.4% of age-group I, 1.1% of age-group II, and none of age-groups III and IV captured June 19–24. By July 13–20, most fish of age-groups I–IV had new growth, and the percentage of those with new growth continued to be greater in the younger age groups (92.9%, 88.9%, 75.0%, and 58.5% of age-groups I–IV,

respectively). Scales of all fish in age-groups I–III and 90.5% of those in age-group IV had new growth by August 4–8.

The relationship between fish length and the time of annulus formation was less well defined, but the larger fish of an age group appeared to begin growth earlier than the smaller fish. Drum in age-groups I–III with new growth on their scales clearly were longer than "nongrowing" fish at the start of the 1958 growing season (table 7). In age-group IV, however, the average lengths of growing and nongrowing fish were identical, even though those with new growth had greater average lengths at the start of the growing season in four of the six catches that were combined in table 7.

Progress of the season's growth in age-groups O–IV (table 8) was remarkably regular. Growth increments increased consistently until early October and changed little thereafter. The length at capture of age-group O fish increased in each period except October 22–27, when the length was 0.1 inch less than October

TABLE 7

*Relation between length of fish and time of onset of growth**

Age and scale growth	Number of fish	Fish length (inches) before start of growth
Age-group I		
Growing	24	4.8
Nongrowing	56	4.6
Age-group II		
Growing	20	7.6
Nongrowing	16	7.4
Age-group III		
Growing	29	9.7
Nongrowing	10	9.4
Age-group IV		
Growing	55	10.9
Nongrowing	35	10.9

*All catches made between June 19 and July 20, 1958; only catches containing both "growing" and "nongrowing" fish were used. Length for nongrowing fish is length at capture; length for growing fish is calculated length at outermost annulus.

2–9. The small changes in length during October suggest that growth was completed or near completion by the end of October. The total seasonal growth of age-groups O–IV in 1958 was respectively 4.1, 2.6, 1.5, 1.0, and 0.8 inches.

Curves fitted by inspection (fig. 2) to the data of table 8 formed the basis for estimates of percentage of the full season's growth completed by each of the age groups during semimonthly periods (table 9). These data show that older age groups completed their period of rapid growth sooner than the younger groups. The greatest growth during a semimonthly period by age-groups II (29.6%), III (33.7%) and IV (32.0%) was made during August 1–15. The maximum growth of fish in age-group I (30.8%) was during August 16–30. No data are available for age-group O from hatching (late June to mid-July) through early August. The most rapid growth of the O-group, however, appears to have been during August. Despite the earlier start of growth in younger age groups (table 6), by July 1–15 age-groups I–IV had each completed a similar portion of total season's growth (12.6–15.9%). At the end of the next period (July 16–31), however, the

older age groups generally had completed a greater percentage of the season's growth (23.8, 34.5, 44.2, and 37.3% for age-groups I–IV, respectively). The difference among the age groups in percentage of season's growth completed decreased slightly by August 16–31 and was again small by September 1–15 (89.9–95.8% complete for all age groups).

TABLE 8

*Amount of season's growth in length completed by age groups of drum captured on various dates during the 1958 growing season**

Period	Age group				
	0	I	II	III	IV
June 19–24	——	0.05	<0.01	0.00	0.00
		(76)	(95)	(45)	(79)
July 13–20	——	0.37	0.18	0.15	0.12
		(14)	(36)	(40)	(94)
August 4–10	1.6	0.8	0.8	0.6	0.4
	(49)	(12)	(9)	(12)	(19)
August 20–26	2.4	1.8	1.0	0.8	0.6
	(306)	(25)	(49)	(37)	(48)
September 10–19	3.6	2.4	1.3	0.9	0.7
	(405)	(62)	(63)	(50)	(63)
October 2–9	4.1	2.6	1.4	0.9	0.7
	(379)	(38)	(31)	(27)	(20)
October 22–27	4.0	2.6	1.5	1.0	0.8
	(423)	(26)	(35)	(25)	(42)

*Growth for age-groups I–IV calculated from the scales; growth data for 0-age group fish are length at capture. Number of fish in parentheses.

TABLE 9

*Percentage of season's growth completed by various age groups during semimonthly periods in 1958**

Period	Age group				
	0	I	II	III	IV
June 16–30	——	3.8	2.8	0.0	0.0
		(3.8)	(2.8)	(0.0)	(0.0)
July 1–15	——	8.8	13.1	15.8	13.3
		(12.6)	(15.9)	(15.8)	(13.3)
July 16–31	——	11.2	18.6	28.4	24.0
		(23.8)	(34.5)	(44.2)	(37.3)
August 1–15	——	27.3	29.6‡	33.7‡	32.0‡
	(47.8)	(51.1)	(64.1)	(77.9)	(69.3)
August 16–31	23.5	30.8‡	18.6	12.6	18.6
	(71.3)	(81.9)	(82.7)	(90.5)	(87.9)
September 1–15	18.6	11.9	9.7	5.3	6.7
	(89.9)	(93.8)	(92.4)	(95.8)	(94.6)
September 16–30	8.1	5.0	5.5	2.1	2.7
	(98.0)	(98.8)	(97.9)	(97.9)	(97.3)
October 1–17	2.0	1.2	2.1	2.1	2.7
	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

*Data based on the curves of figure 2; cumulative percentage of season's growth completed by end of period given in parentheses; season's growth assumed to be complete by October 17.

‡Period of greatest growth.

GROWTH IN LENGTH

Although not all fish of age-groups I–IV could be sexed, the calculated lengths for the first 4 years for age-groups I–IV (table 10) and for fish of age-groups V–XIV (table 11) suggest that males and females grew at the same rate through the 4th year of life. The calculated lengths of table 10 for males and for females are not valid estimates for these age groups (especially groups I and II), however, because they do not include the unsexed fish that had slower growth. Growth estimates for age-groups I–IV therefore were adjusted by assigning unsexed fish as males or females on the basis of the sex ratios for each age group. This assignment was justified because there was no evidence that identification was easier for males than for females and because apportionment on any other basis would have caused the adjusted growth rates of the sexes to differ in age-groups I–IV. The adjusted growth histories of age-groups I–IV are given in tables 12 and 13.

TABLE 10

Calculated total length at end of each year of life of various sex classifications of Lake Erie drum in age-groups I–IV

Age group and sex	Number of fish	Length at capture	Year of life			
			1	2	3	4
I						
Male	24	7.9	5.2	——	——	——
Female	16	7.7	5.1	——	——	——
Unknown	236	5.8	4.7	——	——	——
II						
Male	83	8.8	4.8	7.8	——	——
Female	91	8.7	4.9	7.8	——	——
Unknown	159	7.8	4.8	7.4	——	——
III						
Male	143	10.2	5.2	7.6	9.9	——
Female	94	10.5	5.4	7.8	9.9	——
Unknown	16	9.3	5.0	6.8	8.7	——
IV						
Male	202	11.3	5.2	8.0	9.8	11.0
Female	187	11.5	5.4	8.0	9.7	11.1
Unknown	2	11.6	6.0	8.5	10.2	11.4

TABLE 11

*Calculated total length (inches) of male and female drum in age-groups V–XIV at the end of each of the first 4 years of life**

Sex	Number of fish	Year of life			
		1	2	3	4
Male	148	5.4	8.5	10.8	12.1
Female	104	5.4	8.5	10.7	12.1

*Length are sums of average increments.

Two estimates of general growth, the grand average calculated length and the sum of the average increments, were obtained from the data of tables 12 and 13. Although both are valid, the grand average calculated lengths serve best to show the relation between length and age. The sum of the average increments is more descriptive of actual growth, however, especially under conditions of changing growth rate, and is used in preference to the grand average calculated lengths as an estimate of general growth in length.

Growth based on the sums of the average increments was nearly identical for males and females during the first 4 years of life (tables 12 and 13). In the 5th through the 11th years, however, the females grew more rapidly than the males and, by the end of the 11th year, females were 1.5 inches longer than males. The decrease in the difference between the two sexes to 1.3 inches in the 12th and 13th years reflects the absence of females in age-group XIII, and the slow growth of fish in age-group XIV.

TABLE 12

*Calculated total length (inches) at end of each year of life of each age group, and average growth for combined age groups of female Lake Erie drum**

Age group	Number of fish	Length at capture	Year of life													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14
I	110	6.1	4.8	—	—	—	—	—	—	—	—	—	—	—	—	—
II	174	8.3	4.9	7.6	—	—	—	—	—	—	—	—	—	—	—	—
III	100	10.4	5.4	7.7	9.8	—	—	—	—	—	—	—	—	—	—	—
IV	188	11.5	5.4	8.0	9.7	11.1	—	—	—	—	—	—	—	—	—	—
V	32	13.5	5.5	8.6	10.7	12.1	13.2	—	—	—	—	—	—	—	—	—
VI	55	14.0	5.2	8.3	10.5	11.9	12.9	13.9	—	—	—	—	—	—	—	—
VII	4	16.0	5.8	8.5	10.9	12.0	13.3	14.4	15.4	—	—	—	—	—	—	—
VIII	3	17.5	5.3	9.4	12.1	13.6	14.4	15.3	16.3	17.1	—	—	—	—	—	—
IX	5	17.0	5.6	8.6	10.9	12.5	13.6	14.5	15.1	15.9	16.7	—	—	—	—	—
X	2	18.5	5.7	8.7	11.9	13.7	15.2	16.1	16.6	17.1	17.6	18.3	—	—	—	—
XII	2	20.0	6.0	7.9	11.3	13.1	14.6	15.5	16.0	16.8	17.6	18.5	19.4	19.7	—	—
XIV	1	18.9	5.6	8.3	11.2	12.4	13.2	14.2	14.7	15.9	16.4	16.8	17.2	17.6	18.1	18.9
Grand average calculated length			5.2	7.9	10.0	11.5	13.2	14.1	15.6	16.5	17.0	18.1	18.6	19.0	18.1	18.9
Increment of average			5.2	2.7	2.1	1.5	1.7	0.9	1.5	0.9	0.5	1.1	0.5	0.4	−0.9	0.8
Grand average increment of length			5.2	2.7	2.0	1.4	1.1	1.0	0.7	0.8	0.7	0.8	0.7	0.4	0.5	0.8
Sum of average increment of length			5.2	7.9	9.9	11.3	12.4	13.4	14.1	14.8	15.6	16.4	17.1	17.5	18.0	18.8

*Includes 184 fish in age-groups I–IV lacking sex data, that were assigned as females.

TABLE 13

*Calculated total length (inches) at end of each year of life of each age group, and average growth for combined age groups of male Lake Erie drum**

Age group	Number of fish	Length at capture	Year of life												
			1	2	3	4	5	6	7	8	9	10	11	12	13
I	166	6.1	4.8	—	—	—	—	—	—	—	—	—	—	—	—
II	159	8.3	4.8	7.6	—	—	—	—	—	—	—	—	—	—	—
III	153	10.1	5.2	7.6	9.8	—	—	—	—	—	—	—	—	—	—
IV	203	11.3	5.2	8.0	9.8	11.0	—	—	—	—	—	—	—	—	—
V	45	12.6	5.3	8.2	10.4	11.7	12.4	—	—	—	—	—	—	—	—
VI	52	13.4	5.3	8.3	10.5	11.7	12.5	13.1	—	—	—	—	—	—	—
VII	14	15.0	5.5	9.0	11.4	12.7	13.5	14.3	14.7	—	—	—	—	—	—
VIII	9	15.0	5.5	8.9	11.0	12.5	13.4	14.0	14.5	14.8	—	—	—	—	—
IX	8	15.8	5.1	8.7	10.9	12.3	13.2	13.8	14.6	15.0	15.5	—	—	—	—
X	7	17.6	5.9	9.3	12.1	13.5	14.4	15.2	15.6	16.2	16.8	17.3	—	—	—
XI	3	17.8	5.7	8.3	10.4	12.2	13.3	14.2	15.1	16.0	16.7	17.3	17.6	—	—
XII	5	18.6	6.0	9.2	11.2	12.8	13.6	14.4	15.2	16.0	16.7	17.2	17.7	18.3	—
XIII	5	18.4	5.1	7.7	10.5	12.0	13.5	14.2	14.9	15.6	16.2	16.7	17.3	17.8	18.3
Grand average calculated length			5.1	7.9	10.1	11.4	12.8	13.7	14.9	15.5	16.3	17.1	17.5	18.0	18.3
Increment of average			5.1	2.8	2.2	1.3	1.4	0.9	1.2	0.6	0.8	0.8	0.4	0.5	0.3
Grand average increment of length			5.1	2.8	2.1	1.3	0.8	0.7	0.6	0.6	0.6	0.5	0.5	0.6	0.5
Sum of average increment of length			5.1	7.9	10.0	11.3	12.1	12.8	13.4	14.0	14.6	15.1	15.6	16.2	16.7

*Includes 229 fish in age-groups I–IV lacking sex data, that were assigned as males.

The 1st-year growth of 5.1–5.2 inches was much greater than the growth in any of the following years of life, as is common among fish. Increments decreased sharply in the 2nd through the 5th years, but changed only slightly thereafter; beyond the 6th year, the value varied little for males (0.5 or 0.6 inch) and ranged from 0.4 to 0.8 inch for females. Because of slow growth in the later years of life, attainment of large size required survival to an advanced age. Males reached 12 inches in 5 years, 15 inches in 10 years, and nearly 17 inches at 13 years. Females reached 12 inches in about 5 years, 15 inches in about 8 years, and exceeded 18 inches at 14 years.

COMPARISON OF GROWTH IN LAKE ERIE AND OTHER WATERS

Average growth of drum collected in Lake Erie in 1958 was slower than that reported by Van Oosten (1938) for fish taken in 1927 (table 14). The length advantage of drum taken in 1927 was established principally in the 1st year

TABLE 14

*Length (inches) of drum at the end of different years of life in Lake Erie and in certain other waters**

Area and study	Year of life									
	1	2	3	4	5	6	7	8	9	10
Lake Erie										
Present study										
Male	5.1	7.9	10.1	11.4	12.8	13.7	14.9	15.5	16.3	17.1
Female	5.2	7.9	10.0	11.5	13.2	14.1	15.6	16.5	17.0	18.1
Van Oosten (1938)†	5.8	8.7	10.8	12.4	13.7	15.1	16.0	17.0	——	——
Upper Mississippi River‡										
(Butler and Smith, 1950)	4.9	9.0	11.7	13.4	14.8	16.5	18.1	19.1	——	——
Oklahoma waters§										
(Houser, 1931)										
Rock Creek	3.0	5.1	6.7	8.3	9.6	9.9	——	——	——	——
Altus City Lake	6.1	11.5	17.7	20.5	22.6	26.0	27.4	28.8	30.0	31.0

*Growth estimates are given as grand average calculated lengths, because sums of average increments of length were not available for all stocks shown here.

†Standard length in millimeters calculated by direct proportion (body-scale ratio assumed constant) were converted to total length in inches and recalculated on the basis of the body-scale relationship determined in the present study. Sex not determined.

‡Lengths calculated by empirically determined body-scale relationship (intercept 0.8 inch). Authors found no difference in the growth rate of males and females.

§Lengths were calculated by direct proportion assuming a constant body-scale ratio. Sex not determined.

of life, although growth in the 2nd through the 8th years was also slightly greater than in 1958. In comparison to these 1958 data, drum in 1927 averaged 0.6–0.7 inch larger at the end of the 1st year of life, were 12 inches long 1 year earlier, and were 17 inches 1 to 2 years earlier.

Lake Erie drum captured in 1958 grew more slowly than drum from the upper Mississippi River (Butler and Smith, 1950; table 14). First-year growth of drum in the upper Mississippi River was less than in Lake Erie, but rapid growth in the 2nd and later years enabled them to reach 17 inches in the 7th year—2 to 3 years earlier than the Lake Erie fish. Lake Erie fish grew considerably slower than drum in Altus City Lake, Oklahoma (Houser, 1960), the stock with the fastest recorded growth rate. Growth in the 1st year of life was only slightly better in Altus City Lake but, after the 2nd year, it was more than twice that in Lake Erie. Lake Erie drum, however, grew more rapidly than Rock Creek drum—the stock with the slowest recorded growth (Houser, 1960). First-year

growth in Rock Creek was slow (3 inches) and, although growth improved there in the 2nd and later years of life, drum remained 2.8 to 3.8 inches shorter in Rock Creek than in Lake Erie.

Lake Erie is a moderately favorable environment for growth of drum during the 1st year, but the requirements for sustained good growth in the 2nd and later years of life are met less well, and the advantage of good growth in the first year is soon lost. Thus the growth rate of drum in Lake Erie generally falls below the midpoint of the range of growth in other waters (table 14).

ANNUAL FLUCTUATIONS OF GROWTH IN LENGTH AND THE GROWTH-TEMPERATURE RELATION

The percentage fluctuation of annual growth in length of males and females combined for 1951–57 (table 15) showed less variability in the 1st year than

TABLE 15

*Percentage deviation of growth in length in various calendar years from the 1951–57 average**

Deviation in year of life	Calendar year						
	1951	1952	1953	1954	1955	1956	1957
1st year	8.5	1.2	3.1	1.2	1.2	− 6.6	−8.6
2nd and later years	24.4	4.4	4.4	−4.6	−4.6	−16.3	−8.0

*Sexes combined on an unweighted basis.

TABLE 16

*Air and water temperatures (°F) in western Lake Erie, May-October 1958**

Month	Air	Water	
		Surface	Bottom
May	59.6	57.1	55.3
June	65.2	66.4	65.0
July	73.6	75.6	70.1
August	71.4	75.2	71.6
September	65.8	67.1	66.9
October	56.0	58.4	58.2

*Air temperatures are monthly means from the published records of the U.S. weather station at Sandusky, Ohio. Water temperatures are from fishing stations in western Lake Erie and are averages for 10 to 19 observations made during each month.

in the 2nd and later years of life. First-year growth declined 17.1% in 1951–57. Growth in the 2nd and later years declined 40.7% in 1951–56, but improved markedly in 1957 (8.0%). The wider fluctuations of growth after the 1st year suggests that the factors contributing to fluctuations operate more strongly after the 1st year of life.

The relation between growth and temperature in 1951–57 was tested by calculating coefficients of correlation between annual fluctuations in growth and monthly mean air temperatures recorded at the U.S. weather station at Sandusky, Ohio. These air temperatures showed good agreement with surface- and bottom-water temperatures in western Lake Erie (table 16).

All 63 possible combinations of monthly air temperature for May through October were tested for correlation with growth in the 1st, and in 2nd and later years of life. Growth in the 1st year was not significantly corrected with air temperature in any of the individual months during the growing season (June through October), or with May temperatures, which might influence the early seasonal growth. The combined temperatures for the period May through October also were not correlated with growth in the 1st year of life. Elimination of August and September, however, provided a 4-month combination that gave a good ($p = 0.05$) correlation with growth in the 1st year of life (table 17). Combined temperatures for May, June, July, September, and October; for June, July, and October; and also for May, June, September, and October were correlated with the 1st-year growth at the $p = 0.10$ level. Growth after the 1st year was not significantly correlated with temperature.

Although the general relation for poikilotherms is for metabolic rate to increase with an increase in temperature, it has been demonstrated clearly by Kinne (1960) that there is probably a temperature range over which fish grow most rapidly, and that temperatures above and below this range operate directly on metabolism

TABLE 17

*Coefficients of correlation between 1st-year growth and various combinations of average monthly air temperatures for 1951–57**

Months	Coefficient of correlation
May, June, July, and October	0.754
May, June, July, September, and October	0.717
June, July, and October	0.708
May, June, September, and October	0.671

*Only combinations correlating at the 10% level or higher are given (no correlations at the 10% level or higher were found for growth in the 2nd and later years of life). For 5 degrees of freedom $r = .754$ at the 5% level; at the 10% level $r = .669$.

to cause growth to decrease or stop. During the growth period, temperatures below the optimum would be expected to be correlated positively with growth; negative correlations should be found for temperatures higher than optimum, and temperatures within the optimum range should give no correlation. The correlations for Lake Erie drum indicate that growth in the 1st year of life is independent of temperature during August, and to some extent in September, but is augmented by high temperatures in May-July and in October (table 17). It appears, therefore, that temperatures in Lake Erie usually are near the optimum for 1st-year growth during August and are less than optimum during other months of the growing season. This conclusion is supported by information on seasonal changes in the growth rate of young-of-the-year drum in 1958 (fig. 2). The growth curve for O-group drum, although incomplete, strongly suggests that growth was most rapid during August, when bottom water temperatures were highest (table 16).

The effect of temperature on growth in the 2nd and later years of life is not clear. Although temperature and growth after the 1st year were not significantly correlated, some conformity with the growth-temperature relation shown for 1st-year growth is suggested by a similar trend in annual fluctuations of growth in the 1st, and in second and later years (table 15). Growth in the 2nd

and later years of life, as in the 1st year, was most rapid in August (table 9), when temperatures were highest (table 16), and was slower at other times in the growing season, when temperatures were lower. The failure of growth to show the same correlations with temperature in the 2nd and later years as it did in the 1st-year suggests, however, that the growth-temperature relation of the older drum may be obscured by factors related to age or size.

TABLE 18

*Length-weight relationship of Lake Erie drum**

Number of fish	Average total length (inches)	Average weight (ounces)	
		Empirical	Calculated
5	3.2	0.2	0.2
10	3.7	0.3	0.3
36	4.2	0.5	0.4
27	4.7	0.6	0.6
23	5.2	0.9	0.9
22	5.7	1.1	1.2
31	6.2	1.5	1.5
44	6.7	1.9	2.0
75	7.2	2.4	2.5
107	7.7	2.9	3.0
85	8.2	3.7	3.7
76	8.7	4.4	4.5
75	9.2	5.3	5.3
88	9.7	6.2	6.3
91	10.2	7.2	7.4
136	10.7	8.5	8.6
130	11.2	9.8	9.9
111	11.7	11.2	11.4
67	12.2	12.8	13.1
60	12.7	15.0	14.8
50	13.2	17.2	16.7
42	13.6	19.4	18.4
23	14.2	22.6	21.1
20	14.7	24.7	23.5
16	15.2	26.4	26.1
12	15.7	30.0	28.9
8	16.2	35.3	32.0
5	16.6	33.0	34.5
6	17.2	42.8	38.6
7	17.7	40.0	42.3
5	18.3	48.8	47.0
7	18.7	48.9	50.3
2	19.2	50.5	54.7
1	19.8	62.0	60.3
1	20.1	52.0	63.2
1	22.4	98.0	89.0

*The lengths are true averages for fish in 0.5-inch groups.

LENGTH-WEIGHT RELATION AND GROWTH IN WEIGHT

Differences in weight between the sexes and between mature and immature drum of the same length were so small that an estimate of the general length-weight relation could be obtained from a combination of data for all fish. The equation for length-weight relation determined by a least squares fit of the logarithms of the lengths and weights (table 18) was:

$$\text{Log } W = -2.3192 + 3.1615 \log L,$$

where W = weight in ounces,

and L = total length in inches.

The agreement between calculated and empirical weights was generally close (table 18). Discrepancies were randomly distributed, and were small at lengths less than 16.2 inches. Disagreements were greater among data for the larger fish, but did not exceed 4.2 ounces for fish 16.2 to 19.2 inches long.

TABLE 19

Calculated weight (ounces) at the end of each year of life*

Year of life	Male		Female	
	Calculated weight	Increment	Calculated weight	Increment
1	0.8	0.8	0.9	0.9
2	3.3	2.5	3.3	2.4
3	7.0	3.7	6.7	3.4
4	10.2	3.2	10.2	3.5
5	12.7	2.5	13.7	3.5
6	15.2	2.5	17.5	3.8
7	17.5	2.3	20.6	3.1
8	20.2	2.7	24.0	3.4
9	23.0	2.8	28.4	4.4
10	25.6	2.6	33.2	4.8
11	28.4	2.8	37.9	4.7
12	32.0	3.6	40.8	2.9
13	35.2	3.2	44.6	3.8
14	——	——	51.2	6.6

*Weights were computed from the general length-weight equation and the average increments of length of tables 13 and 14.

TABLE 20

Sex composition of drum in Lake Erie, 1958

Age group	Number of females	Number of males	Percentage males
I	16	24	60
II	91	83	48
III	94	143	60
IV	187	202	52
V	32	45	58
VI	55	52	49
VII	4	14	78
VIII	3	9	75
IX	5	8	62
X	2	7	78
XI	——	3	100
XII	2	5	71
XIII	——	5	100
XIV	1	——	0
Total	492	600	55

Growth in weight (table 19) was determined from the general length-weight equation and the sums of average increments of length shown in tables 12 and 13. The annual increments of weight were similar for the sexes in the 1st 4 years of life, but thereafter (except in the 12th year) the increments of the females were

substantially larger. First-year increments of males and females were 0.8 and 0.9 ounce, respectively. Increments increased sharply after the 2nd year, and were 3.2–3.7 ounces in the 3rd and 4th years. The increment of the males decreased to 2.5 ounces in the 5th and 6th years and was even lower (2.3 ounces) in the 7th year, but thereafter showed a general increase. The annual increments in weights of females also showed a general increase with age, but fluctuated more widely than did those of the males.

Growth in weight was slow; both males and females required nearly 4 years to reach 10 ounces. After the 4th year of life, females gained weight more rapidly than the males. Females averaged 1 pound in the 6th year and 2 pounds in the 10th. Males did not weigh 1 pound until the 7th year and required 12 years to reach 2 pounds.

TABLE 21

*Relation between length and maturity**

Length interval	Male			Female		
	Immature	Mature	Percentage mature	Immature	Mature	Percentage mature
7.0– 7.4	44	1	2	44	—	0
7.5– 7.9	40	2	5	58	—	0
8.0– 8.4	43	2	4	23	—	0
8.5– 8.9	20	5	20	24	—	0
9.0– 9.4	25	14	36	28	1	3
9.5– 9.9	41	17	29	34	5	13
10.0–10.4	21	37	64	34	3	8
10.5–10.9	18	50	74	55	10	15
11.0–11.4	15	55	79	47	6	11
11.5–11.9	4	39	91	32	4	11
12.0–12.4	4	28	88	17	5	23
12.5–12.9	—	18	100	10	8	44
13.0–13.4	—	28	100	9	11	55
13.5–13.9	—	10	100	5	13	72
14.0–14.4	—	9	100	4	8	67
14.5–14.9	—	10	100	3	4	57
15.0–15.4	—	10	100	2	4	67
15.9–15.9	—	4	100	1	2	67

*Immature fish include a number of individuals of undetermined sex that were assigned as males or females on the basis of the sex ratio of fish in each 0.5-inch interval. All fish shorter than 7.0 inches were immature; all longer than 15.9 inches were mature.

SEX RATIO, MATURITY, AND SPAWNING

Males were more abundant than females in 11 of 14 age groups (table 20). In age-groups I–VI, 54% were males, but the ratio in age-groups VII and older increased to 75% males. The number of fish in age-groups VII and older was small, however, and the sex ratio for all 14 age groups was 55% males.

Drum reached maturity between 7.0 and 15.9 inches; males matured at smaller sizes than females (table 21). The smallest mature male was in the 7.0–7.4-inch interval; 64% of the males were mature at 10.0–10.4 inches, and 100% were mature above 12.4 inches. The smallest mature female was in the 9.0–9.4-inch-length interval; 55% were mature at 13.0–13.4 inches, and all females longer than 15.9 inches were mature. First maturity and 100% maturity of males occurred at lengths respectively 2.0 and 3.5 inches shorter than for females.

Males mature at an earlier age than females (table 22). The youngest mature

males were in age-group II and all in age-groups VI and older were mature. First maturity and 100% maturity in females were reached in age-groups III and VII, respectively. The percentage of mature females in each of age-groups III–VI was consistently smaller than that of mature males in the same age group.

Ages at maturity reported by Daiber (1953) for 174 Lake Erie drum captured in the spring of 1948 were greater than those of this study. First maturity occurred among males in age-group IV and 100% maturity was reached in age-

TABLE 22

*Relation between age and sexual maturity of Lake Erie drum**

Age group	Percentage mature	
	Males	Females
II	3 (159)	0 (174)
III	38 (153)	7 (100)
IV	77 (203)	13 (188)
V	91 (45)	50 (32)
VI	100 (52)	65 (55)

*Number of fish in parentheses. All fish in age-group I were immature and all older than VI were mature.

TABLE 23

*State of maturity of drum at various times during the spawning period in 1958**

Dates	Percentage of mature males			Percentage of mature females		
	Unripe	Ripe	Spent	Unripe	Ripe	Spent
April 25–May 8	86 (6)	14 (1)	—	100 (3)	—	—
May 17–June 2	100 (18)	—	—	100 (8)	—	—
June 19–24	52 (33)	48 (30)	—	33 (5)	67 (10)	—
July 13–20	13 (12)	20 (18)	66 (59)	—	23 (8)	77 (27)
August 4–8	—	—	100 (17)	—	—	100 (3)

*Number of fish in parentheses.

group VII; females matured first in age-group V and were 100% mature in age-group IX. Because of possible problems related to differences in growth rate, gear selectivity, and segregation within stocks, it is uncertain whether there is a true difference between the two periods in age at maturity. The samples of the present study, however, provide a sound basis for an estimate of the relation between age and maturity in 1958, because they were taken throughout the entire western basin of Lake Erie and include catches during the spawning season, when the state of sexual development is most easily determined.

The spawning season of drum in western Lake Erie in 1958 fell between June 24 and August 4 and may have reached a peak in early July (table 23). A single ripe male was captured during April 25-May 8, but no others were taken until mid-June. During June 19–24, 48% of the mature males were ripe. Spent males first appeared on July 13–20, when they made up 66% of the mature fish. No ripe or freshly spent males were captured after July 20. The first ripe females were taken June 19–24 and made up 67% of the mature females. Spawning had passed its peak by July 14–20, when 23% of the females were ripe and 77% were spent. All mature females taken after July 20 were spent.

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